Modeling and simulation of mechanical damping in nanocomposites

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Abstract

The talk will summarize research efforts dealing with three-dimensional nonlinear modeling of nanocomposite materials made of polymer matrix and Carbon Nanotubes.

The developed constitutive theory describes the hysteretic response of non-functionalized nanocomposites caused by the shear stick-slip between the carbon nanotubes and the polymer chains of the hosting matrix. The theory combines the mean-field homogenization method based on the Eshelby equivalent inclusion theory, the Mori-Tanaka homogenization approach, and the concept of inhomogeneous inclusions with inelastic eigenstrains introduced to describe the shear stick-slip [1,2].

The evolution of the inelastic eigenstrain flow is regulated by an incremental law based on a micromechanical adjustment of the von Mises function associated to the interfacial stress discontinuity, so as to mimick a 3D Bouc-Wen constitutive model [3,4].

The material optimization in terms of damping capacity of such nanocomposites is addressed. To this end, efficient and accurate numerical solution schemes capable of simulating cyclic analysis quite rapidly are discussed.

A specialised time-integration scheme implementation is illustrated whereby the Extended Average Mean Value Theorem is combined with a formulation of the Impulse-Momentum Law while benefiting from the convergence rules of Newton-Raphson solvers [5,6].

The talk will show a variety of numerical results, including some validation of the proposed model compared with the experimentally obtained force-displacement cycles, and a simulation campaign providing the sensitivity to the variation of the model parameters in order to achieve an optimal nanocomposite material design.

References

1. Mura, T., Micromechanics of Defects in Solids, Martinus Nijhoff, The Netherlands, 1987.
2. Benveniste, Y. (1987) A new approach to the application of Mori–Tanaka's theory in composite materials, *Mechanics of Materials* **6**, 147–157.
3. Casciati, F. (1995) Stochastic dynamics of hysteretic media, *Probabilistic Methods in Applied Physics. Lecture Notes in Physics*, vol. 451, Krée, P. and Wedig W. (Eds.), Springer, Berlin Heidelberg, 270–283.
4. Formica, G., Talò, M. and Lacarbonara, W. (2014) Nonlinear modeling of carbon nanotube composites dissipation due to interfacial stick-slip, *International Journal of Plasticity* **53**, 148–163.
5. Casciaro, R. (1975) Time evolutional analysis of nonlinear structures, *Meccanica* **10**, 156–167.
6. Formica, G. and Lacarbonara, W. (2017) Three-dimensional modeling of interfacial stick-slip in carbon nanotube nanocomposites, *International Journal of Plasticity* **88**, 204–221.